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BUDDING IN HYDRA.

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Budding in hydra has received the attention of only a few investigators. Our principal information as to the origin of the bud is derived from Lang's[1] account. He describes the bud as beginning by an increase in volume and division of the interstitial cells. After the ectoderm becomes thickened, the mesoglea disappears and the cells pass from the ectoderm into the endoderm. This process continues until the ectoderm becomes reduced to its normal thickness. The mesoglea then reforms and a cavity appears in the thickened endoderm, which becomes the enteron of the new individual.

The main object of the present paper will be to give a brief account of the origin and development of the buds in hydra, more especially their manner of growth and what cells contribute most to their rapid formation.

The species studied, *Hydra viridis* and *Hydra* sp.? (Brauer) differ somewhat from Lang's account. The mesoglea does not disappear and the ectodermal cells do not pass into the endoderm. The bud, however, begins by an increase in volume and division of the interstitial cells. After they have increased once or twice in volume, as shown in Fig. 1, there is a slight outbulging of the ectoderm, which is scarcely perceptible. Fig. 2 represents the condition of the interstitial, ectodermal and endodermal cells in the origin of the bud as they appear more highly magnified. A few mitotic figures are visible. No amitotic divisions were observed. The endodermal cells contain numerous food particles, which may pass intact through the mesoglea into the ectoderm. The cells directly concerned in the formation of the bud are well supplied with food, while the remaining cells of the parent hydra show a scarcity. Many of the endodermal cells in the distal half of the hydra have a glandular appearance and are most active in

[1] Lang, Albert, "Uber die Knospung bei *Hydra* und einigen Hydropolypen," *Z. wiss. Zool.*, Vol. 54, 1892.

the secretion of the digestive fluid, which aids in the breaking up of the food in the enteron, while those endodermal cells in the region of growth, "the formation of buds and sexual organs," are the most active in ingesting the partly digested food from the enteron and preparing it for diffusion into the ectodermal cells.

The ectoderm and endoderm in the early formation of the bud, which are quite uniform, soon become differentiated into two dis-

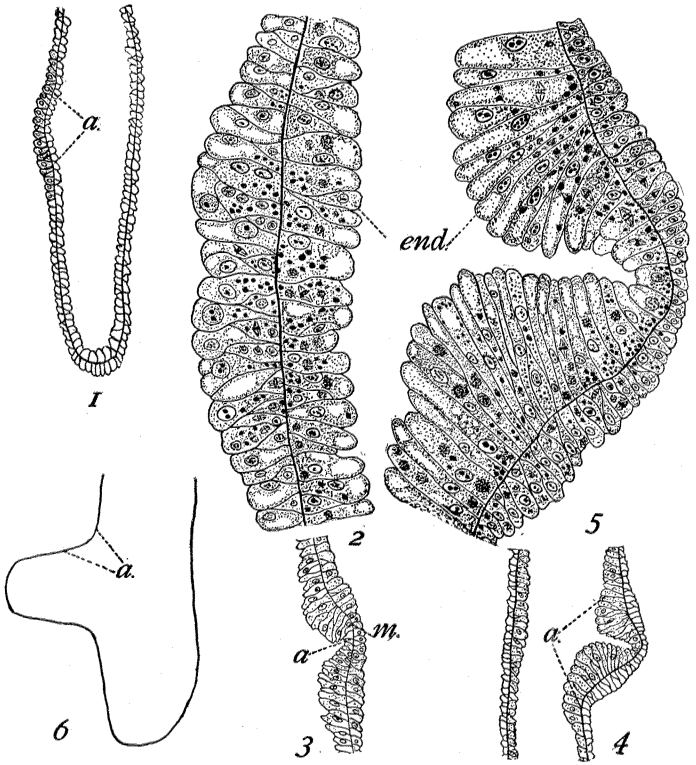

FIG. 1. Longitudinal section of hydra showing the origin of bud at *a*.

FIG. 2. Part of preceding figure at *a*. × 80.

FIG. 3. Longitudinal section through wall of hydra showing curvature of mesoglea and beginning of enteron in forming bud. *m*, mesoglea; *a*, enteron.

FIG. 4. Stage of development a little later than preceding. *a*, the point of junction between parent and bud.

FIG. 5. A portion of preceding figure at *a*, which includes the entire area in the formation of bud. *end.*, endoderm. × 90.

FIG. 6. Diagram of a longitudinal section of parent hydra with bud. *a*, active growing region in formation of bud.

tinct regions. The cells more centrally placed (Fig. 3, *a*), which correspond to the distal end of bud, become inactive, while those on either side of the central region continue active, divide rapidly and contribute almost entirely to the rapid growth of the bud. There is a slight curvature in the mesoglea (Fig. 3, *m*), and the enteron of the new individual becomes apparent. In a stage little later than the preceding (Fig. 4), the relation of bud to parent and the condition of cells is more plainly represented. Fig. 5, a portion of Fig. 4 at *a*, represents the entire area that contributes directly to the growth of the bud. The cells at the apex of the forming bud are small. Those on either side are larger and more active in the process of division and growth. Their contents is very similar, showing an abundance of food material and cytoplasmic granules.

The ectoderm and endoderm at the junction of the parent and bud (Fig. 7) divide very rapidly and become the most active growing region in the production of the new individual. The remaining cells of the bud seldom divide. The formation of the tentacles is similar to that of the buds. The cells corresponding to their basal ends take the most active part in their growth. The mouth is formed at the distal end of the bud by a breaking through of the ectoderm.

The rate of growth of the bud is determined by the amount of food present. In an active feeding hydra, the buds are often completely formed in thirty to forty hours. While in those hydras with a moderate supply of food the buds grow very slowly and may require four or five weeks or even more time for their complete development. In the latter instance after the buds are nearly formed, they will be absorbed in the absence of food. In the process of absorption the cell walls of the bud become imperceptible and the cell contents presents the appearance of a complete syncytium. When the buds are nearly absorbed, if the hydra is again supplied with food, the buds very seldom reform. In a few instances the buds were neither absorbed nor reformed, but remained attached to the parent as permanent individuals. Tentacles were formed later.

When the buds have reached their complete development the ectodermal cells at the proximal end undergo a rapid change

(Fig. 8, *ect*). They become more narrow, elongated and present the appearance of glandular cells. They have the power to

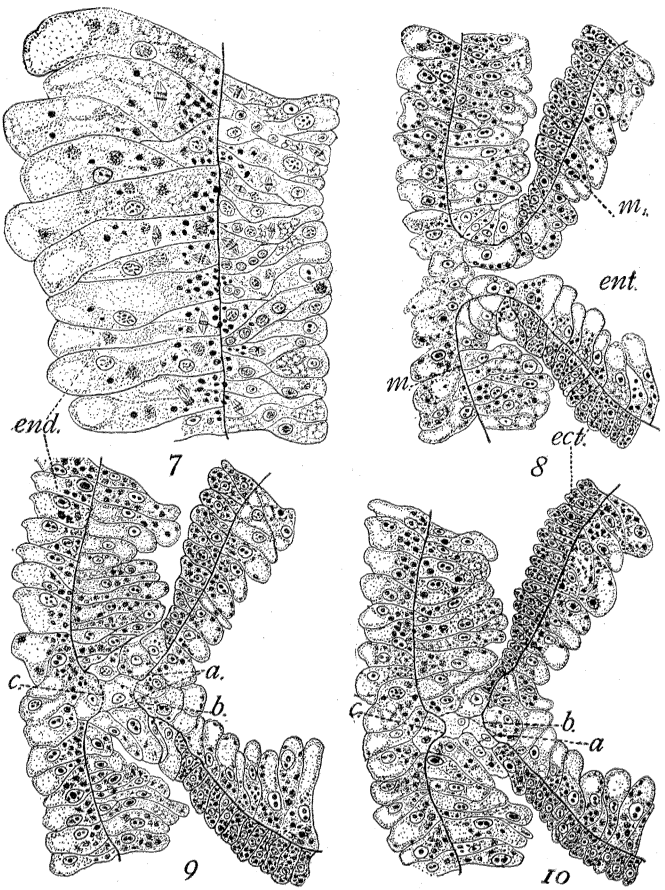

FIG. 7. Longitudinal section at junction of parent hydra and bud, taken at *a* in Fig. 6. *end.*, endoderm. × 100.

FIG. 8. Longitudinal section through base of mature bud and wall of parent hydra. m_1, mesoglea of bud; *m*, mesoglea of parent; *ect.*, glandular ectoderm; *ent.*, enteron of bud.

FIG. 9. Longitudinal section showing change of mesoglea in separation of parent and bud at *a*, and formation of new mesoglea at *b* and *c*. The endodermal cells at proximal end of bud have united. *a*, mesoglea between bud and parent becoming thinner; *b*, new mesoglea of bud; *c*, new mesoglea of parent.

FIG. 10. Longitudinal section showing completion of mesoglea at *b* and *c* and persistence of old mesoglea at *a*.

secrete a sticky substance before the bud becomes separated from the parent.

The first step in the process of separation of bud from parent occurs in the mesoglea. Fig. 8 represents the condition of mesoglea and cells before separation begins. The mesoglea, which connects the bud with parent, is uniform throughout. But almost immediately it becomes thinner and thinner until it is indistinguishable from the ordinary cell wall (Fig. 9, *a*). The enteron leading from the parent to the bud becomes discontinuous by the union of the endodermal cells. New mesoglea is now formed at the extreme basal end of the bud (Fig. 9, *b*) and at the point of former union with the parent at *c*. The mesoglea, which is more of a gelatinous nature, increases in thickness by means of secretion from the endodermal cells and soon reaches its normal condition (Fig. 10, *b* and *c*). After the formation of the mesoglea is complete, the bud remains attached to the parent by a few ectodermal and endodermal cells, as shown in Fig. 10. The former connecting mesoglea is represented by the dotted lines at *a*. The cells between the dotted lines, which are endodermal, become external to the newly formed mesoglea and take the position of ectoderm. Whether these cells persist or not and function as ectoderm is difficult to say, as there is no possible means of following them in the process of separation of bud from parent.

Summary.

1. The initial step in the formation of bud in hydra is found in the interstitial cells.

2. The most active region of growth in the formation of the bud is found at the junction of the forming bud and parent, where the cells divide very rapidly and contribute almost entirely to its growth.

3. When the bud is nearly formed the ectodermal cells in the basal region become transformed into granular glandular cells, which later secrete a glutinous substance for attachment of hydra.

4. The rate of growth in buds is controlled by the amount of food present. Starvation after buds are nearly complete often causes their complete absorption by parent hydra.

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